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The association of current smoking behavior with the smoking behavior of parents, siblings, friends and spouses

Jacqueline M. Vink, Gonneke Willemsen & Dorret I. Boomsma

Department of Biological Psychology, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands

Correspondence to:

Jacqueline M. Vink

Department of Biological Psychology

Vrije Universiteit Amsterdam

Van der Boechorstraat 1

1081 BT Amsterdam

The Netherlands

Tel: + 31 20 444 8958

Fax: + 31 20 444 8832

E-mail: jm.vink@psy.vu.nl

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ABSTRACT

Aims To examine the association of current smoking behavior of adolescents and young adults with the smoking behavior of their parents, siblings, friends and spouses.

Design Using survey data from a large twin-family sample, the association between the smoking behavior of participants and that of their family members, friends and spouses was investigated by calculating the relative risk. To disentangle sex and age differences, calculations were carried out separately for males and females and for three different age groups: 12–15, 16–20 and 21–40 years old.

Findings The smoking behavior of the participants was significantly influenced by the smoking behavior of parents, siblings and friends, but all relative risks decreased with age. No differences in relative risk were found between having older or younger smoking siblings. Within each age group, the relative risk to smoke when having a smoking friend was comparable to the relative risk to smoke when having a smoking same-age and same-sex sibling. For the older participants, the relative risk to smoke was higher for monozygotic (MZ) twins with a smoking co-twin than for dizygotic (DZ) twins with a smoking co-twin. Most findings were sex-dependent: same-sex smoking family members influenced smoking behavior more than opposite-sex family members. The significant association of the smoking behavior of spouses decreased with age, which suggests that assortment for smoking is based on similarity at the time dating began.

Conclusions The results highlight the importance of both social and genetic influences on smoking behavior, with genetic influences increasing with the age of the participant.

KEYWORDS Friends, parents, relative risk, siblings, smoking, spouses, twins.

INTRODUCTION

Using data from a large twin-family sample from the Netherlands Twin Register, we explored whether the relative risk to be a smoker when having smoking parents, smoking siblings or smoking friends is different for young adolescents (aged 12–15 years) who are legally not allowed to buy tobacco, older adolescents (16–20 years)

and adults (21–40 years). Several studies have shown associations between the smoking behavior of adolescents and that of their family members and friends (Jensen & Overgaard 1993; Wang *et al.* 1995; Distefan *et al.* 1998; O'Loughlin *et al.* 1998; Whithers *et al.* 2000; Alexander *et al.* 2001; Bauman *et al.* 2001; Boyle *et al.* 2001).

Most of these studies investigated smoking behavior in adolescents and young adults aged 12–18 years.

Whether the effect of smoking family members or friends still influences smoking behaviour after this age is not clear. West *et al.* (1999) included 16–23 years olds and concluded that the period from late adolescence to early adulthood is still of importance for the uptake of regular smoking. Adolescents and young adults were included in our study of smoking behavior, and we hypothesized that, in line with earlier studies (Bauman *et al.* 2001; Wang *et al.* 1995), the relative risk to smoke when family or friends smoke will remain stable across all age groups.

When analysing data from family members, we distinguish between the influence of parents and the influence of siblings. In general, studies that include the smoking behavior of siblings have shown that having siblings who smoke increases an adolescent's risk of smoking two- to fourfold (Jensen & Overgaard 1993; Wang *et al.* 1995; O'Loughlin *et al.* 1998; Moran *et al.* 2000; Whiters *et al.* 2000; Boyle *et al.* 2001). Two studies concluded that having older smoking siblings increase a subject's risk of being a smoker (Jensen & Overgaard 1993; Wang *et al.* 1995). Although those studies have included older siblings, no studies have directly compared the association between subjects' smoking behavior and having younger or older smoking siblings. If adolescents and young adults imitate the smoking behavior of people in their environment, we expect that the relative risk to smoke is higher when older siblings are smokers than when younger siblings are smokers. In contrast, if the association between the adolescents' smoking behavior and the smoking behavior of siblings is caused by genetic influences, the relative risk to be a smoker should be equal for having younger or older smoking siblings.

The study of Wang *et al.* (1995) included both siblings and friends and reported that having smoking friends formed a higher risk for adolescents' smoking than having smoking older siblings. This was also found by Jensen & Overgaard (1993), but not by Swan *et al.* (1990). However, siblings usually are a few years older or younger than the proband, while friends are often more similar in age. Inclusion of same-age siblings, i.e. twins, may solve a problem regarding the comparison of siblings and friends. In this study, data are available for dizygotic twins, who share the same proportion of genes as other siblings. We investigated whether the influence of friends is higher than the influence of same-age siblings by comparing the relative risk to smoke when having a smoking same-age sibling—i.e. dizygotic twins—with the relative risk to smoke when having a smoking best friend.

If age differences are important for influencing smoking behavior it is also likely that parents who smoke have a lower impact on smoking behavior than siblings who smoke. Generally, studies have found a rather low but significant influence of parental smoking on the smoking behavior of adolescents (Green *et al.* 1991; Meijer *et al.*

1996; Distefan *et al.* 1998; Boyle *et al.* 2001). The risk ratios in those studies ranged from 1.6 to 2.1 when both parents smoked, and from 1.4 to 2.2 when at least one parent smoked. Therefore, we expect low relative risks for smoking when parents smoke. On the other hand, the genetic resemblance of parents and offspring is the same as among full siblings. So if genetic similarity explains familial resemblance, no differences between the relative risk to smoke when having smoking parents and the relative risk to smoke when having smoking siblings is expected, unless different genes are expressed in the parental and the offspring generation.

In contrast to the dizygotic (DZ) twins, who share on average 50% of their genes, monozygotic (MZ) twins are genetically identical. It has been well established from twin studies that there is a familial aggregation for smoking behavior and that a large part of this aggregation is due to genetic factors (Heath & Madden 1995; Sullivan & Kendler 1999). The genetic influence on smoking behavior is likely to depend on the age composition of the sample. Genetic factors seem less important in younger age cohorts than in older cohorts (Heath & Madden 1995). So we hypothesize that the differences between the risk to smoke when having a MZ smoking co-twin and having a DZ smoking co-twin increases with age.

The effect of smoking family members and friends may differ for men and women. Wang *et al.* (1995) found higher odds ratios for adolescents' smoking behavior for same-sex smoking siblings or friends than for opposite-sex smoking siblings or friends. In the present study, the authors explore whether the relative risk to be a smoker when having smoking brothers or sisters is different for males and females (e.g. brother–brother versus brother–sister).

Similarly, studies have reported that maternal, and not paternal, smoking significantly influenced adolescent smoking (Hover 1988; Brenner & Scharrer 1996; Herlitz & Westholm 1996), although the opposite has also been reported (Shamsuddin & Abdul Harris 2000). Only a few studies have included both the sex of the parent and the sex of the participant (Swan *et al.* 1990; Wang *et al.* 1995). The study of Wang *et al.* (1995) did not show significant influences of smoking mothers or smoking fathers on their sons and daughters aged 14–18 years, while the study of Swan *et al.* (1990) showed a significant risk to smoke for females when their mother smoked but not when their father smoked. For males, smoking behavior was not associated with that of either parent. Because the two studies that investigated the association between smoking father and smoking mother separately for males and females have found different results, the present study also investigated the relative risk to smoke for males and females in relation to maternal and paternal smoking.

Spouses or long-term partners form a special group of 'best friends' who may have a significant influence on each other's smoking behavior. Price & Vandenberg (1980) reported spouse similarity for several variables, including current smoking. In a large survey among women in the USA, the odds that a woman's spouse was a current smoker was 5.5 times greater if she was a current smoker than if she did not smoke (Ogden *et al.* 1997). Moreover, in a Dutch study, the correlation between husband and wife for current smoking status ($r=0.43$) was larger than for smoking history ($r=0.18$) (Boomsma *et al.* 1994). In contrast, Graham & Der (1999) concluded that partner's smoking status was not a predictor of tobacco consumption among women. Similarity between spouses could be due to several factors; assortment may be based on similarity at the time dating began, or phenotypes may have converged during the years of marriage because of reciprocal influences or shared living conditions (Price & Vandenberg 1980). Price *et al.* (1981) suggested that for smoking the convergence of phenotype was the most likely explanation. To explore this theory, we have a unique dataset of twins aged 25–30 years and their spouses, as well as a dataset of the twins' parents aged 30–45 years and 46–65 years. Assuming that the duration of the relationship for the younger spouses is shorter than for the older spouses, we would expect higher relative risks for the older age groups if convergence of phenotype is the correct explanation.

In short, this paper investigates if the smoking behavior of family members (parents, older/younger/same-age siblings) and friends (most friends, best friend, spouse) elevates an individual's risk to smoke as a function of age and sex.

PARTICIPANTS AND METHODS

Longitudinal study on personality and health-related behaviors

In 1991, the Netherlands Twin Register (NTR) started a large-scale twin-family study on personality and health-related behaviors. Addresses of twins were obtained from city council registries, as described in Boomsma *et al.* (2000) and Koopmans *et al.* (1999). New twins were recruited throughout the study period. From 1991 onwards, the twin families received a questionnaire every 2 or 3 years. Twins were asked to participate every time (1991, 1993, 1995, 1997 and 2000); parents only in 1991, 1993 and 1995 and siblings only in 1995, 1997 and 2000 (Table 1). Sample selection and response rates are described in detail in Koopmans *et al.* (1999) and Boomsma *et al.* (2000). Some individuals participated

Table 1 Number of participants in the longitudinal twin-family study of the Netherlands Twin Register.

	1991	1993	1995	1997	2000
Fathers	1483	1778	1573	—	—
Mothers	1623	1919	1685	—	—
MZ twins	1304	1576	1382	1371	2196
DZ twins	2091	2309	2022	1760	2380
Zyg unkn	—	—	11	12	35
Siblings	—	—	1482	1434	1475
Spouses	—	—	—	—	706
Total	6501	7582	8155	4577	6592

Fathers = fathers of the twins; mothers = mothers of the twins; MZ = monozygotic twins; DZ = dizygotic twins; Zyg unkn = zygosity of twins unknown; siblings = additional siblings, besides the twins; spouses = spouses of twins

once, whereas others participated on multiple occasions. If subjects participated more than once, the answers on the first questionnaire they completed were used in the analysis. For each relative risk calculation, data were only included if family members or spouses participated in the survey at the same time.

The surveys contained items on health, lifestyle and personality (e.g. alcohol consumption, smoking, physical exercise, general health and personality). To analyse smoking behavior in twins, their siblings, parents, friends and spouses, two questions were selected from the questionnaires. The first was, 'did you ever smoke?'. This question had three answer categories: 'no'; 'just a few times to try'; 'yes'. The second question was, 'how often do you smoke now?', with the following answer categories: 'I have never smoked'; 'I quit smoking'; 'I smoke less than once a week'; 'I smoke more than once a week but not every day'; 'I smoke daily'. Based on the answers to these questions, participants were classified as current smokers or non-smokers (combining never smokers and ex-smokers). The classification was cross-validated using other questions such as, 'how many cigarettes do you smoke per day?'. To investigate the influence of age, twins were divided into three age groups: 12–15 years (young adolescents, legally not allowed to buy tobacco in the Netherlands), 16–20 years (older adolescents) and 21–40 years (adults).

Twin pairs

To calculate the relative risk to be a smoker when having a smoking co-twin, the data of the questionnaires of 1991 (1679 twin pairs), 1993 (984 new twin pairs), 1995 (five new twin pairs), 1997 (450 new twin pairs) and 2000 (480 new twin pairs) were used. In total, 3598 twin pairs (7196 subjects) were included in the analyses.

Twins and siblings

Siblings of twins were asked to participate in the survey for the first time in 1995. To calculate the relative risk to be a smoker when having full siblings who smoke, the data of the twins and their siblings were used from the surveys in 1995 (1714 families), 1997 (618 new families) and 2000 (711 new families). In total, questionnaire data were available for 3043 families (7906 participants). Due to incomplete questionnaires, smoking status was known for 7828 individuals (twins and siblings). For 1501 families, no additional siblings (besides the twins) participated. For the other families, the mean number of additional siblings was 1.34 and the mean age difference with the twins was 3.5 years (SD 2.2). To determine the relative risk to be a smoker as a function of having older or younger siblings who smoke, we determined whether the selected participants (twins and siblings) did have older brother(s), older sister(s), younger brother(s) and younger sister(s), and if at least one of those siblings was a smoker.

Parents

The biological parents of the twins were included in the study in 1991 (1499 fathers and 1642 mothers), 1993 (908 new fathers and 987 new mothers) and 1995 (40 new fathers and 13 new mothers). The questions on smoking were answered by 2447 fathers and 2633 mothers. The mean age of the fathers was 47.3 years (SD 5.4) and of the mothers 45.1 years (SD 5.0). For the calculations of the relative risk to smoke when having a smoking spouse, the parents were divided into two age groups: 30–45 and 46–65 years.

Peers/best friend

In the 1993 questionnaire, twins were asked if their best friend smoked. The answer categories were: 'never-smoker'; 'ex-smoker'; 'smokes sometimes'; 'smokes 1–10 cigarettes/day'; 'smokes more than 10 cigarettes/day'. The question was answered by 2772 of the 3884 twins (71.4%) who completed a questionnaire in 1993. The remaining 1112 participants missed the question because it was the last in a series of questions on the smoking behavior of father, mother, co-twin, five brothers and five sisters. When the twins reported that their best friend was a never-smoker or an ex-smoker, the best friend was classified as a non-smoker; when the twins reported that their best friend smoked sometimes, smoked 1–10 cigarettes a day or more than 10 cigarettes a day, the best friend was classified as a smoker. The relative risk to be a smoker when having a smoking best friend compared with having a non-smoking best friend was calculated.

In addition, the twins were also asked in 1993 how many of their friends were regular smokers. The answer categories were: 'no-one'; 'a few friends'; 'half of the friends'; 'most friends'; 'all friends'. The question was answered by 3828 participants. The relative risk of being a smoker was calculated for subjects who reported that most or all of their friends were regular smokers compared with subjects who reported that none, a few or half of their friends were smokers. Mean age when the twins filled in the questionnaire was 17.34 (SD 3.07) for the males and 17.39 (SD 3.15) for the females.

Spouses

In 2000, all twins aged between 25 and 30 years were asked if they had a partner and, if so, if their partner was willing to fill in a questionnaire. In total, 706 partners completed the questionnaire. The mean age of the male spouses was 30.1 (SD 4.3) and of the female spouses 26.1 (SD 3.9).

Statistical analyses

The prevalence of smoking was calculated using SPSS 10.0 for Windows. The relative risk was used to summarize associations between the smoking status of the participants and parental/sibling/friend/spouse smoking. The relative risk was calculated as the ratio of the percentage of smokers with smoking family members/friends to the percentage of smokers with non-smoking family members/friends. The relative risk and the 95% confidence intervals were calculated using Epi-Info 2000 version 1.1 (Centers for Disease Control of the World Health Organization).

RESULTS**Prevalence of smoking**

For the prevalence of smoking, the following general trends were found in the data of twins and siblings: the prevalence of current smoking was higher for males than for females and higher for older participants than for younger participants (Table 2a). For the parents, the prevalence of smoking was higher in the 30–45-year-old group than in the 46–65-year-old group for both mothers and fathers (Table 2b).

Age differences

We first investigated whether the relative risk to smoke when having smoking family members and when having smoking friends was stable across the three age groups. Results showed that having smoking family members and

Table 2a Prevalence of smoking for siblings and twins (data collected in 1995–2000). For each age group, the percentage of smokers (% smokers), the total number of participants (*n*) and the mean age are shown.

	12–15 years			16–20 years			21–40 years		
	% smokers	<i>n</i>	Mean age	% smokers	<i>n</i>	Mean age	% smokers	<i>n</i>	Mean age
MZM	8.2	97	14.4	25.3	368	18.1	31.4	344	24.9
DZM	18.8	64	14.6	30.7	267	18.0	41.4	295	24.9
DOS males	11.1	171	14.5	32.0	250	18.2	41.9	315	25.0
Brother	19.8	81	13.6	30.1	236	18.3	39.6	535	26.2
MZF	11.1	171	14.4	22.5	543	18.1	28.1	734	26.8
DZF	8.7	104	14.4	26.5	332	18.1	30.0	523	25.7
DOS females	11.3	80	14.5	29.6	253	18.2	35.2	341	25.0
Sister	10.8	83	13.7	29.5	261	18.3	34.3	636	26.7

MZM = monozygotic males; DZM = dizygotic males; DOS males = males of a dizygotic opposite-sex twin; brother = additional brother of a twin; MZF = monozygotic females; DZF = dizygotic females; DOS females = females from a dizygotic opposite-sex twin; sister = additional sister of a twin.

Table 2b Prevalence of smoking for parents and spouses (data of parents collected in 1991–95 and data of spouses collected in 2000). The percentage smokers (% smokers), the total number of participants (*n*) and the mean age are shown.

	% smokers	<i>n</i>	Mean age
30–45-year-old fathers	41.4	1040	42.9
46–65-year-old fathers	36.1	1200	50.8
30–45-year-old mothers	33.7	1413	41.9
46–65-year-old mothers	25.6	894	49.9
Male spouses (20–53 years)	34.6	413	30.1
Female spouses (18–47 years)	22.6	257	26.1

smoking friends significantly elevated the relative risk to smoke in all age groups. However, the relative risk to smoke when mother smoked, when siblings smoked or when friends smoked was elevated more for the young adolescents (12–15 years) than for the older adolescents and adults. Across all age groups, the relative risk to smoke when both parents smoked was lower or comparable to the relative risk to smoke when having smoking siblings. Having smoking siblings (other than co-twin) presented a lower risk than having smoking friends (Table 3a).

The risk to be a smoker was calculated separately for having a smoking older brother, older sister, same-age DZ brother, same-age DZ sister, younger brother and younger sister. As the minimum age to participate in the questionnaire study was 12 years, almost no data were available for younger siblings of participants aged 12–15. No differences were found between the influences of having older or younger smoking siblings. In most age groups, the relative risk to smoke when having smoking same-age siblings (DZ co-twin) seemed somewhat higher than the relative risk to smoke when having younger or older siblings, although these differences were not significant.

Results showed a strong association between being a smoker and having smoking friends. For example, when 12–15-year-old girls had a smoking best friend the relative risk to smoke was almost 17 times higher compared with girls having a non-smoking best friend. For participants aged 16 years or older, the relative risk to smoke when having smoking friends or a smoking best friend was lower than for the younger participants but still significant. The relative risk to smoke when having a smoking same-age sibling was not significantly different from the relative risk to smoke when having smoking friends or having a smoking best friend.

In MZ twins (genetically identical), the risk to be a smoker when their co-twin smoked was high. The relative risk to smoke when the co-twin smoked was significantly higher for MZ twins compared with DZ twins in the older age groups but not in the youngest group.

Sex differences

In addition to the effect of age, sex differences were investigated. Table 3a summarizes the influence of smoking parents. For males, having both a smoking father and a smoking mother elevated the risk to smoke. In contrast, for females, the relative risk to smoke was not significantly influenced by a smoking father for the participants aged 12–15 and 21–40 years, while a smoking mother significantly elevated the risk to smoke in all age groups.

A trend for sex differences was found for the relative risk to smoke when having smoking siblings. For example, for the 12–15-year-old females, having a smoking same-sex sibling of the same age elevated the risk to smoke 16 times, while having a smoking opposite-sex sibling of the same age elevated the risk to smoke 'only' 6.5 times. However, the confidence intervals showed that this difference was not significant. The trend that the relative risk to smoke is higher when same-sex siblings smoke

Table 3a Relative risk when having smoking siblings, friends or parents. For each age group, the relative risk (RR), the 95% confidence interval (95% CI) and the total number of participants (n) are shown.

		12–15 years			16–20 years			21–40 years		
Smoking		RR	95% CI	n	RR	95% CI	n	RR	95% CI	n
Men	Older brother(s)	5.23	2.18–12.55	136	3.04	2.04–4.53	283	1.51	1.14–2.00	289
	DZ twin brother	13.80	4.57–41.66	146	3.33	2.22–5.00	237	1.93	1.08–3.43	82
	MZ twin brother	22.4	8.53–58.82	195	10.82	6.50–18.00	258	4.02	2.45–6.60	132
	Younger brother(s)	–	–	16	3.40	2.38–4.87	249	1.72	1.36–2.19	481
	Older sister(s)	2.42	1.02–5.72	119	1.78	1.34–2.36	284	1.64	1.28–2.11	327
	DZ twin sister	6.74	2.63–17.32	285	2.58	1.68–3.94	214	1.67	0.74–3.74	55
	Younger sister(s)	–	–	7	2.29	1.34–3.90	117	1.16	0.85–1.59	263
	Best friend	10.22	4.75–21.97	328	3.87	2.94–5.09	508	2.10	1.52–2.92	208
	Most/all friends	7.53	4.15–13.04	540	2.82	2.34–3.40	832	2.06	1.63–2.60	303
	Father	2.00	1.24–3.23	893	1.35	1.12–1.63	1285	1.41	1.14–1.74	374
	Mother	2.46	1.55–3.90	939	1.41	1.18–1.69	1412	1.24	1.01–1.52	415
	Both parents	3.06	1.66–5.64	623	1.58	1.24–2.01	841	1.62	1.21–2.16	222
Women	Older brother(s)	3.58	1.10–11.60	140	1.66	1.11–2.48	306	1.35	1.05–1.73	392
	DZ twin brother	6.47	2.63–15.90	285	2.39	1.54–3.70	211	1.60	0.83–3.10	54
	Younger brother(s)	–	–	21	1.96	1.07–3.58	145	1.67	1.17–2.37	247
	Older sister(s)	6.67	2.16–20.61	130	2.21	1.61–3.02	372	2.22	1.74–2.84	453
	DZ twin sister	16.13	7.61–34.18	184	3.64	2.47–5.37	284	2.97	1.80–4.91	188
	MZ twin sister	25.60	10.49–62.48	271	13.39	8.11–22.12	377	4.32	3.05–6.11	227
	Younger sister(s)	–	–	16	3.06	2.08–4.50	254	2.35	1.82–3.03	632
	Best friend	14.93	8.54–26.12	552	5.23	3.92–6.98	800	2.73	1.90–3.92	343
	Most/all friends	16.65	10.00–27.71	662	3.61	2.95–4.43	1023	2.61	1.96–3.48	417
	Father	1.38	0.85–2.25	1018	1.75	1.43–2.14	1434	1.18	0.91–1.53	407
	Mother	2.35	1.51–3.66	1106	1.80	1.50–2.17	1607	1.52	1.19–1.93	446
	Both parents	2.16	1.19–3.93	728	2.35	1.80–3.08	918	1.51	1.05–2.17	240

DZ = dizygotic; MZ = monozygotic.

	Age of participant Mean (range)	Age of spouse Mean (range)	RR	95% CI	n
Men	27.4 (24–31)	25.9 (18–47)	2.90	2.07–4.05	252
	42.9 (30–46)	41.6 (32–54)	2.43	2.11–2.80	1035
	50.9 (46–65)	47.9 (34–63)	1.87	1.62–2.16	1167
Women	27.4 (24–31)	30.1 (20–46)	3.58	2.42–5.30	417
	42.9 (30–46)	44.4 (30–61)	2.71	2.31–3.18	1374
	50.9 (46–65)	51.6 (38–73)	2.04	1.62–2.56	854

Table 3b Relative risk to smoke when having a smoking spouse. The mean ages of the participant and spouse, the relative risk (RR), the 95% confidence interval (95% CI) and the total number of participants (n) are shown.

than when opposite-sex siblings smoke was also seen for younger and for older siblings. For both men and women, this effect was strongest in the younger age groups.

Data on the smoking behavior of the spouses of twins aged 24–31 years showed that the relative risk to smoke was about three times higher when having a smoking spouse compared with having a non-smoking spouse (Table 3b). Furthermore, data on smoking were available for spouses aged 30–46 years and 46–65 years. The risk to smoke when having a smoking spouse decreased from the younger age group to the older age groups for men as well as for women.

DISCUSSION

Most studies have investigated risk ratios for smoking in young adolescents, aged between 12 and 18. The present study also included older participants up to 40 years of age. Our data showed that the relative risks to smoke when family members or friends smoked were still significant in adults. However, the relative risks were clearly higher for the young adolescents compared with the adults. Within each age group, the relative risk to smoke is highest when having smoking friends, somewhat lower when having smoking

younger/older siblings and lowest when having smoking parents.

Most previous studies did not distinguish between younger or older siblings (Maziak & Mzayek 2000; Moran *et al.* 2000; Whithers *et al.* 2000; Boyle *et al.* 2001), or only included older siblings (Wang *et al.* 1995; Jensen & Overgaard 1993). It is likely that, when younger siblings imitate the smoking behavior of older siblings, the relative risk to be a smoker when having smoking older siblings is higher than the relative risk to be a smoker when having younger siblings. Boyle *et al.* (2001) used the youngest sibling as dependent variable in a logistic regression analysis and concluded that the dominant influence of substance use behavior appeared to be from older siblings to younger siblings. In the present study, the relative risk to be a smoker was not different for having smoking younger siblings and having smoking older siblings. The younger siblings of the adults (21–40 years) are likely to have already completed the smoking initiation process, and therefore differences may not be evident in this sample. However, the younger siblings of the 16–20-year-olds may not have completed the smoking initiation process. Still no differences were observed between having smoking younger or older siblings in this younger group. As the minimum age to participate in the questionnaire study was 12 years, almost no data were available for younger siblings of participants aged 12–15. Although the results do not necessarily exclude imitation, they suggest imitation is not the only explanation for the similarity in the smoking behavior of siblings. Other mediating factors for smoking behavior, including genetic factors, therefore play a role.

The strongest test for genetic influences on smoking behavior is the comparison of the degree of similarity of smoking behavior in MZ and DZ twin pairs. As shown, in the youngest group the relative risk to smoke when having a smoking MZ co-twin did not differ significantly from having a smoking DZ co-twin. In contrast, for the older participants results showed differences between MZ and DZ twins, indicating genetic influences on smoking behavior. Studies in genetically informative samples (mostly twin studies but also adoption and family studies) have shown that genetic factors are important for smoking behavior, but seem less important in younger age cohorts (Heath & Madden 1995; Sullivan & Kendler 1999). This is supported by the fact that in the older groups the relative risks to smoke were higher for MZ twins with a smoking co-twin than for DZ twins with a smoking co-twin.

A considerable risk to be a smoker was found when most or all friends were smokers or when the best friend was a smoker. This finding is in line with results from other studies (Hover 1988; Jensen & Overgaard 1993; Sasco *et al.* 1993; Meijer *et al.* 1996; Moran *et al.* 2000;

Alexander *et al.* 2001). An individual can select his or her own friends in contrast to his or her family members. Similarity of smoking behavior within a peer group can be due to 'influence' (individuals imitate the behavior of the peer group to fit in) or 'selection' (individuals choose friends whose behavioral patterns are similar to their own) (Engels *et al.* 1997). Possibly, adolescents with a certain genetic predisposition actively seek out certain environmental experiences that may increase their risk for the development of some behaviors (Scarr & McCartney 1983). Data from a longitudinal study among Dutch secondary school students demonstrated that although influence and selection processes both contributed to peer group homogeneity, the largest part of similarity in smoking status had to be attributed to selection (Engels *et al.* 1997). The similarity of friends can be used as an example of an active genotype-environment (GE) correlation, which occurs when a particular genotype is associated with the selection or creation of a particular environmental circumstance (Rowe 2002). Madden *et al.* (2002) described model-fitting techniques to resolve the contribution of selective friendship and reciprocal peer environmental influences to peer resemblance using cross-sectional data from pairs of siblings or twins and their peers. They included a reciprocal environmental influence of the behavior of one peer on the behavior of a sibling and vice versa. A major limitation of the approach is the assumption that each sibling chooses friends independently from his or her brother or sister. Therefore, methods to examine peer similarity in behavior may not be valid for samples that include a large number of siblings reporting on the behavior of the same friend(s), such as may be observed in the case of siblings who are very close in age or in samples of twins.

Attempts to explain adolescent cigarette smoking often consider the smoking behavior of friends as the most important factor—more important than smoking siblings. However, friends are usually of the same age while siblings are not. Unique to this study is the possibility to compare the relative risk to smoke when having smoking friends with the relative risk to smoke when having smoking same-age siblings (DZ twins). We found that within each age group the relative risk to smoke when having a smoking friend is comparable with having a smoking same-age and same-sex DZ sibling. These results suggest that the age of the other person is just as important as the age of the participant. Future studies should take into account the age difference between the participant and their siblings and friends.

The importance of age difference is in line with the relatively low risks we found for having smoking parents. Osler *et al.* (2001) found adoptees' smoking behavior was not associated with adoptive or biological parental smok-

ing, whereas the adoptees' smoking behavior was associated with their full siblings' smoking behavior. The authors suggest that this finding supports a genetic influence on smoking within the same generation. In line with the study of Osler *et al.* (2001), we found a lower relative risk to smoke in parent-offspring pairs than in sibling pairs. Although it is possible that genes get switched on or off with increasing age or that different genes are operating at different ages, it is also possible that the results are due to different environmental or social influences in the two generations. This hypothesis can be tested with an extended parent-twin design, including young twins, their parents and twins of the same age as the parents, as described by Snieder *et al.* (1997).

The present study also investigated whether the relative risk to smoke for males and females is different for same-sex and opposite-sex family members. Sex-dependent influences of smoking parents were found. Our results are in line with Swan *et al.* (1990), who reported a significant relative risk to smoke for women when their mother smoked and no significant risk ratio when their father smoked. The only other study that distinguished between both sex of the parent and sex of the participant did not find a significant association for smoking behavior (Wang *et al.* 1995).

Similar to the association between subjects' smoking and parental smoking, the association with siblings' smoking tended to be sex-dependent. In line with the results of a study by Wang *et al.* (1995), the relative risk to be a smoker was elevated more when having same-sex smoking siblings than when having opposite-sex smoking siblings, especially for the participants aged between 12 and 20.

Regrettably, data on the sex of the friends were not available. However, the best friend is often of the same sex. It is likely that, in line with results from smoking family members, same-sex friends influence smoking behavior differentially than opposite-sex friends.

Spouses can be considered as a special type of opposite-sex 'best friend'. We included three adult groups with data on spouses. For 24–31-year-old participants, the relative risk to smoke was about three times higher when having a smoking spouse compared with having a non-smoking spouse. Because Price *et al.* (1981) suggested the convergence of phenotype was the most likely explanation for smoking behavior, we expected the relative risks to smoke to be lowest in the youngest group and highest in the oldest group. The opposite was found: having a smoking spouse was a larger risk factor for smoking in younger than in older age groups, for men as well as for women. Assuming that the duration of the relationship is shorter for the younger spouses than for the older spouses, our data suggest that assortment for smoking is based on similarity at the time dating began.

Limitations of the study

As relative risks were calculated for having one or more smoking siblings, compared with having only non-smoking sibling(s), it was not possible to include the age of the sibling in the univariate analyses; some individuals have more than one sibling.

The data on smoking from twins, siblings and parents were self-reported. Self-reported smoking status is usually considered a satisfactory way to classify smoking in epidemiological studies. The smoking behavior of friends was reported by the twins. Bauman & Fisher (1996) found that perceptions of friends' smoking behavior were more strongly correlated than actual reports to adolescent smoking behavior. It seems that people project their own smoking behavior onto that of their friends. Although the results of this study suggest the effect is not large, it may be that relative risk for friends' smoking is slightly overestimated.

In this paper, the association between subjects' smoking behavior and the smoking behavior of family and friends is investigated using univariate statistics. Univariate analyses do not adjust for other variables as would be possible with multivariate statistics. However, in multivariate statistics, if a particular variable correlates with another variable that has explanatory power, it may be excluded from the model although it correlates with smoking on the univariate level. Therefore, we first investigated those variables at a univariate level. Longitudinal data are available for a smaller sample, and multivariate longitudinal analyses are currently being prepared for a further paper.

Overall, for all age groups, the smoking behavior of parents and siblings increased the chances of smoking in the participants. The smoking behavior of friends and spouses was also associated with the smoking behavior of the participants. The results highlight not only the importance of social and genetic influences, with genetic influences increasing with the age of the participant, but also show that most findings are sex- and age-dependent. Possibly, different mechanisms for smoking behavior occur in different age groups and in males and females.

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